Welcome to the VR Industry Forum (Hybrid) Event!

The session will start at 3pm CET / 6:00am Pacific time.

Please note the session is being recorded and will be made available after the event via the VRIF website.

Please keep yourself muted during the presentation segments to help minimize disruptions.

Thank you,
VRIF organizers
Volumetric Guidelines Masterclass & Workshop
(Hybrid event)
VR Industry Forum

Mauricio Aracena (Ericsson)
VRIF President
20th June, 2022
Agenda

• Introduction
• Volumetric Guidelines Masterclass
• “VR and AR Security update – preparing for a secure Metaverse”
  – Mick O’Doherty, Technology Solutions Manager, Irdeto
• “Metaverse Audio”
  – G Yoon, Director of Business Development, Gaudio Lab, Inc.
• Wrap up
VRIF – Mission Statement

- Purpose according to Bylaws:

  “To further the widespread availability of high quality audiovisual VR experiences, for the benefit of consumers”

- Non-profit organisation established during CES 2017, after a year of informal meetings
Who Are We?

- Cate me
- ERICSSON
- Fraunhofer
- HUAWEI
- interdigital
- ir.deta
- GAUDIO
- NOKIA
- PARACOSMA

VRIF – 2022
VRIF – Four parallel tracks

- VR360
- Volumetric
- Social VR
- 5G Cloud
## Guidelines WG Roadmap

<table>
<thead>
<tr>
<th>VR360</th>
<th>Volumetric</th>
<th>Social VR</th>
<th>5G Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3DOF</strong></td>
<td><strong>6DOF – VR/AR</strong></td>
<td><strong>Telecommunication aspects of real-time VR communication</strong></td>
<td><strong>Guidelines x.x</strong></td>
</tr>
<tr>
<td>Guidelines 1.1 &amp; 2.0</td>
<td>Volumetric 1.0</td>
<td>Consumer • Enterprise</td>
<td>• How to use 5G to reach low complexity (thin) devices</td>
</tr>
<tr>
<td>▪ Capture, Production &amp; Human factors</td>
<td>▪ Capture &amp; Production</td>
<td>• Virtual representation of users</td>
<td>• Cloud and Edge based processing functions VR/AR</td>
</tr>
<tr>
<td>▪ Security</td>
<td>▪ Storage &amp; Compression</td>
<td>• Sharing live experiences</td>
<td></td>
</tr>
<tr>
<td>▪ Distribution Use Cases</td>
<td>▪ Point Clouds</td>
<td>• Analysis of NW requirements</td>
<td></td>
</tr>
<tr>
<td>▪ Download</td>
<td>▪ Meshes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Video on demand</td>
<td>▪ Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Live streaming</td>
<td>▪ Delivery Use Cases</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Broadcast</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Video on demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Second Screen XR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ “Live sport personal point of view”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guidelines 2.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Live VRdeployments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ OpenXR (Khronos API)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guidelines 2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Viewport independent (VPI) 8K recommendation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guidelines 2.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Unconstrained HEVC OMAF v2 profiles – any resolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Viewport independent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Viewport dependent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ Multiple Viewpoints and overlays (OMAF v2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volumetric 1.y</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ VVC profiles for Volumetric &amp; Interop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2022 and beyond
Volumetric Video Guidelines Masterclass

- Volumetric use cases
- Volumetric video production workflow
- Volumetric streaming end-2-end architecture
- Media Profiles
Volumetric Use Cases

• Volumetric streamings of assets
• Live sport: “personal view”
• Second screen XR
• Social VR: realistic avatar representation

https://www.svgeurope.org/blog/headlines/bt-sport-on-its-vision-for-augmented-live-sports-broadcasting-becoming-reality-with-5g/
Volumetric Video Production Workflow

- Point Cloud based path
- Mesh-based path
# Volumetric Capture systems

<table>
<thead>
<tr>
<th>Camera Types</th>
<th>Number of Cameras</th>
<th>Resolution</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGB</td>
<td>32 RGB (HHI, Volucap, 4DViews)</td>
<td>2 MPixel (2k)</td>
<td>green screen</td>
</tr>
<tr>
<td>RGB-D</td>
<td>53 RGB + 53 IR (Microsoft MRC)</td>
<td>8 MPixel (4k)</td>
<td>lit background</td>
</tr>
<tr>
<td></td>
<td>64 RGB (Korea Immersive Studio)</td>
<td>20 MPixel (5k)</td>
<td>unconstrained</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 MPixel (8k)</td>
<td></td>
</tr>
</tbody>
</table>

Others
- 4DViews
- I8
- Mantis Vision

Metastage
Fraunhofer HHI
Volucap
Volograms
What is a Point Cloud?

• Set of 3D points,
• not ordered,
• no relationship between them (unlike meshes)

• Each point has
  • a X,Y,Z location in 3D space
  • and possibly additional attributes, such as
  • Texture colour, e.g. YUV or RGB
  • Reflectance, transparency, ...
  • Timing, e.g. in frames
Point Cloud vs Mesh creation processing

1. Depth map of single stereo view
2. Point Cloud
3. Meshed point cloud
4. Reduced mesh
5. Reduced mesh - Texturing
Volumetric streaming: end-2-end

Vol. Content Provider
- Volumetric Assets
- TV & Movie Production

Vol. Content Provider
- 2D content
- VR360 content
- 3D overlays

Vol. Service Platform

RGB/RGB-D acquisition → depth estimation → 3D data fusion → 3D point cloud

point cloud coding → point cloud streaming → real-time decoding in AR/VR app → rendering in AR/VR app

mesh processing → mesh encoding → mesh streaming

Flat screen
AR Glasses
VR HMD
Challenge to transmit point clouds

- Imagine a dynamic point cloud (model / asset) with
  - ~1M points per frame, each point has
  - three 10Bit 3D coordinates (XYZ), and
  - three 8Bit RGB values, requires
  - 1 620 Mbps uncompressed at 30 frames/s

- That is for a single simple model (asset)
- Much more complex models already exist
- 8Bit colour would not be sufficient for HDR or WCG
- More advanced features such as reflectance or transparency require additional data
Volumetric streaming: end-2-end

Volumetric Streaming

PCC Encoding

- point cloud coding
- mesh processing
- mesh encoding
- mesh streaming

PCC Decoding

- point cloud streaming
- mesh streaming

Vol. Content Provider

- 2D content
- VR360 content
- 3D overlays

Vol. Service Platform

- Volumetric Assets
- TV & Movie Production

Vol. Content Provider
Volumetric streaming: end-2-end

- Point Cloud Compression (PCC)
  - MPEG V3C V-PCC based reusing 2D Video (e.g. HEVC)
- Streaming Protocol (PCC)
  - DASH Streaming
Volumetric Video Guidelines

Media Profiles

- Video
  - HEVC Main10 V-PCC Basic Unconstrained

<table>
<thead>
<tr>
<th>Media Profile</th>
<th>Codec</th>
<th>CodecGroup</th>
<th>Toolset</th>
<th>Reconstr.</th>
<th>Level</th>
<th>Brand</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEVC Main10 V-PCC Basic Unconstrained</td>
<td>V3C V-PCC ISO/IEC 23090-5 [2]</td>
<td>HEVC Main10</td>
<td>V-PCC Basic</td>
<td>Unconstrained</td>
<td>1.5</td>
<td>v3mt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/IEC 23090-5 clause A.3</td>
<td>ISO/IEC 23090-5 clause H.15.4.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/IEC 23090-5 clause H.15.5.1</td>
<td>ISO/IEC 23090-5 clause A.6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/IEC 23090-10 clause A.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Audio
  - No new audio profile has been added to this Guidelines, for previous audio profile please refer to Guidelines 2.3
Video Point Cloud Compression (V-PCC)

• Reuse existing video codecs for compressing geometry and texture
• Point clouds are converted into three different video sequences
  – Geometry
  – Texture
  – Occupancy
• Additional metadata is generated
V-PCC Technology Concept Encoding

Input → 3D Patch segmentation → 2D Image packing → Metadata → Texture → 2D Video coding → Geometry → 2D Video coding → Occupancy → 2D Video coding → Multiplexer → Compressed bitstream
V-PCC Decoder

1. Compressed bitstream
2. Demultiplexer
3. Metadata
4. Texture
5. Geometry
6. Occupancy
7. 2D Video decoding
8. Geometry/Attribute Reconstruction
9. Geometry Post-Processing (e.g., smoothing)
10. Attribute transfer & Smoothing
11. Reconstructed Point Cloud
DASH Streaming

- The Guidelines specifies two designs for enabling streaming of V3C V-PCC content
  - Single-track mode
  - Multi-track mode – *preferred for bandwidth adaptation*
# Device Performance

<table>
<thead>
<tr>
<th>Test device</th>
<th>Toolset</th>
<th>FPS</th>
<th>AR on</th>
<th>AR off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samsung Note 10+ (Adreno 640)</td>
<td>Basic</td>
<td>42</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>38</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Huawei P30pro (Mali-G76 MP10)</td>
<td>Basic</td>
<td>42</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>36</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Google Pixel 2XL (Adreno 540)</td>
<td>Basic</td>
<td>30</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>24</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>One Plus 7 pro (Adreno 640)</td>
<td>Basic</td>
<td>40</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>37</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>

## V-PCC Basic Rec0 results (Nokia experiments)

- Results from Nokia and Huawei indicate that V-PCC Basic has broad support on legacy mobile clients, while V-PCC Extended is at the limit of computational capacity.
Demonstration

25 Mbps  
13 Mbps
Many thanks to our speakers!

- Mick O’Doherty
- G Yoon
Interested in joining or knowing more

www.vr-if.org/join

Industry mailing list – open to all: http://goo.gl/4xZgbt
LinkedIn group: https://www.linkedin.com/company/vr-industry-forum